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# AN INVESTIGATION OF PHYTOPLANKTON GROWTH AND RELATIONSHIPS IN THE CEDAR RIVER SYSTEM, IOWA JULY 24-28, 1961

PUBLIC HEALTH SERVICE, KANSAS CITY, MISSOURI

1961

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All reaches of the Cedar River system above Cedar Rapids and down to its junction with the Ohio River possess the necessary nutrients and physical characteristics to support dense algal growths when climatological conditions permit. Rivers are dominated by phytoplankton that occupies streams in response to climatological factors. Under these conditions local actions are largely restricted to determination of densities attained in individual reaches. More critical nutrients for plant growth are supplied by surface wash of fertilized farmlands and sewage and other wastes discharged from cities. Tastes and odors developed in the Cedar River are attributed to excessive microorganisms in the water.

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# AN INVESTIGATION OF PHYTOPLANKTON GROWTH AND RELATIONSHIPS IN THE CEDAR RIVER SYSTEM, IOWA, JULY 24-28, 1961

by:

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and
Wesley E. Smith

U.S. Dept of Health, Education & Welfare
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# An Investigation of Phytoplankton Growth and Relationships in the Cedar River System, Iowa, July 24-28, 1961

by
Joe K. Neel and Wesley E. Smith*

During early summer of 1961 the Cedar Rapids, Iowa, public water supply, which is taken from the Cedar River, developed tastes and odors that severely taxed purification at the water treatment plant. The condition appeared to be due to microorganisms and it endured from late May until early August, demanding the attention of the Iowa State Department of Health, which conducted field studies and special analyses, and eventually the notice of the Iowa Conservation Department when the flesh of fishes taken from the Iowa and Cedar Rivers and from the Mississippi below the mouth of the Iowa reportedly became unpalatable. By that time water had apparently gained a strong taste and odor potential in the Iowa River below its confluence with the Cedar, all along the Cedar River below the mouth of Shellrock River, and up the Shellrock to Lake Albert Lea, Minnesota. Investigations by the Iowa State Department of Health suggested that these developments were attributable to microorganisms and hinted that Lake Albert Lea may have started the affair by discharging algae that assumed dominance in all river reaches conveying its discharge to the Mississippi. The Division of Public Health Engineering, Iowa State Department of Health, issued a Water Pollution investigation report July 20, 1961, that covered the Cedar River from Cedar Falls to Cedar Rapids.

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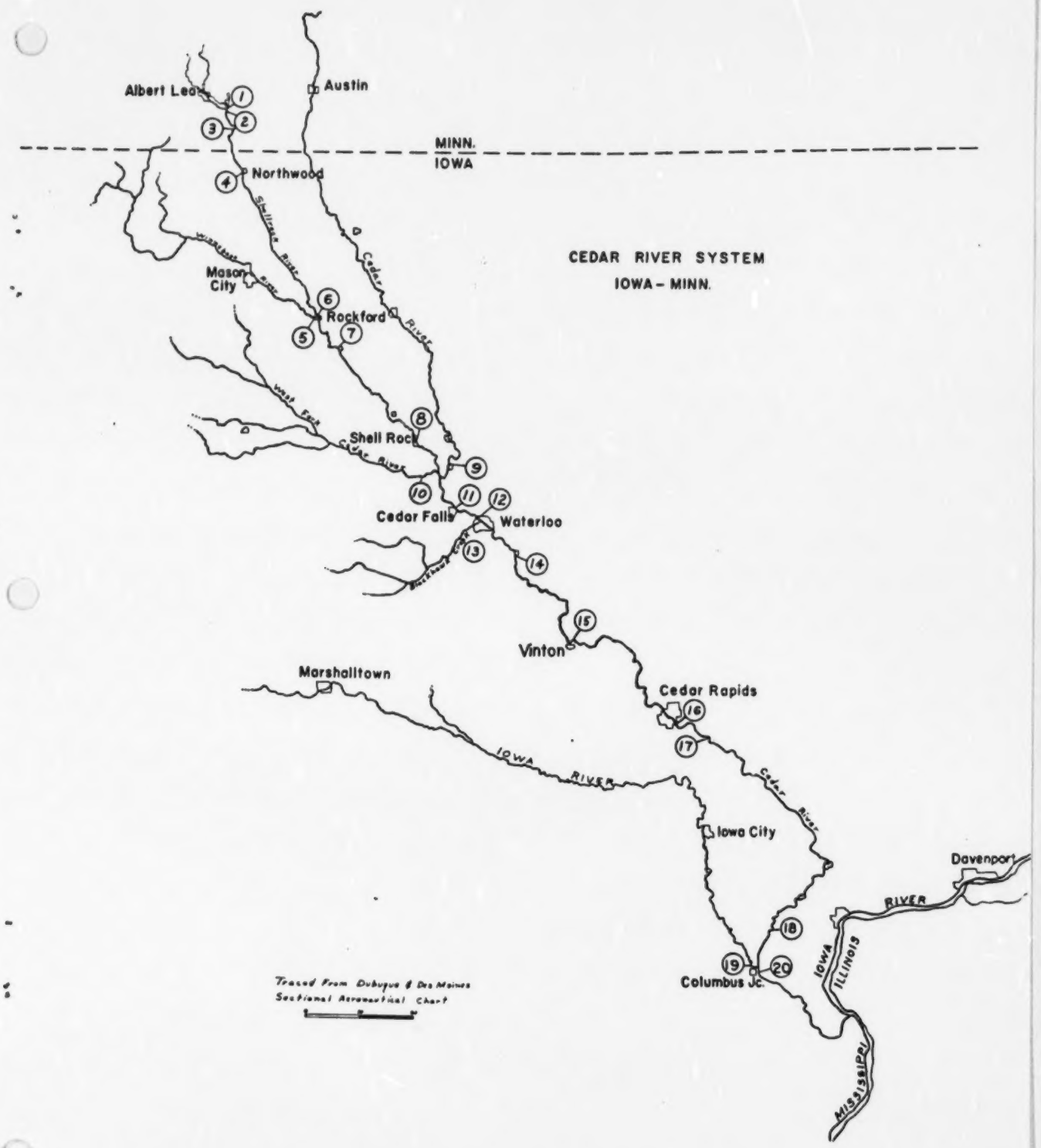
This report delineated water uses and wastes discharged to the above river reach, and listed chemical and biological analyses. It concluded that tastes and odors in the Cedar Rapids water supply were caused by large numbers of algae that were provided with nutrients from soil wash and liquid wastes. Actinomycetes were also mentioned in this regard. It was assumed that favorable climatic conditions played a large role in this particular development.

The study reported herein was planned before issuance of the above report and had as its objectives greater familiarity with conditions promoting such a state of affairs in the Cedar River system, degree of carry-over from certain regions, and influences in the Mississippi. However, rainfall and increased runoff destroyed opportunity for tracing growths into the Mississippi and the last phase was not attempted. Personnel at the Cedar Rapids water plant when contacted July 27 indicated that tastes and odors were declining in severity.

## DESCRIPTION

The two major branches of the Cedar River, the Cedar and Shellrock, begin in south central Minnesota and take a generally parallel southeasterly course through Iowa to their junction north of Cedar Falls (Figure 1). The Cedar joins the Iowa River near Columbus Junction in Louisa County, Iowa, and the Iowa River empties into the Mississippi shortly upstream from New Boston, Illinois. From Lake Albert Lea to its junction with the Cedar, the Shellrock flows about 96 miles; from its head to the same point the Cedar traverses approximately 112 miles, and 256 miles from its head to its mouth in the Iowa River; the Iowa enters the Mississippi after it flows about 28 miles beyond its junction with the Cedar. Major tributaries to the Shellrock are the Winnebago River and the West Fork of the Cedar River. The Cedar River has a number of tributaries not shown in Figure 1. Black Hawk Creek, which enters near Waterloo, was sampled during this study.


CEDAR RIVER SYSTEM
IOWA – MINN.
MINN.
IOWA
Albert Lea
Austin
Northwood
Mason City
Rockford
Shell Rock
Cedar Falls
Waterloo
Vinton
Marshalltown
Cedar Rapids
Iowa City
Columbus Jc.
Davenport
Shellrock River
Winnebago River
Cedar River
West Fork
Beaver Creek
IOWA RIVER
Cedar River
IOWA
ILLINOIS
RIVER
MISSISSIPPI
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Traced from Dubuque & Des Moines
Sectional Aeronautical Chart

CITY-62-619

The Cedar and Shellrock Rivers flow through farmlands and sometimes past wood lots and other small forested areas. They and their tributaries go near or through several towns and cities (named or indicated in Figure 1), most of which add a load of waste that has usually undergone some form of treatment. Both rivers contain a number of low head dams, some now deteriorating and some still playing a role in human affairs. On the Shellrock River, dams were noted at the outlet from Lake Albert Lea, at Rockford, Marble Rock, and Shellrock. Dams were seen on the Cedar at Waverly, Janesville, Cedar Falls, Waterloo, and at Cedar Rapids. Others occur on both rivers. Although these streams largely course through open farmlands, their banks are generally tree-lined and water is usually partially shaded. Conditions at each sampling station are noted in Table 1.

## CHEMICAL FEATURES

A number of chemical analyses conducted during the course of this study (Table 2) showed photosynthesis to be prevalent in all river reaches examined on July 24, 25, and 26. On July 27 the Cedar River and tributaries below Waterloo were filled with surface runoff from heavy rains that fell during the night of July 26. Oxygen concentration, which had been supersaturate at all stations analyzed through July 26 (includes Station 12), fell to less than 5 ppm at Stations 14 and 17. Station 16, in the impoundment at Cedar Rapids, had not been affected by surface runoff when visited at 2:20 p.m. July 27. In addition to increasing oxygen concentration, photosynthesis raised pH, produced $CO_3$ alkalinity, and reduced $HCO_3$ alkalinity. Low oxygen concentrations at Stations 14 and 17 were associated with pH values below 8.0 and zero $CO_3$ alkalinities. Since the Cedar River is influenced by municipal wastes from Waterloo and Cedar Rapids at Stations 14 and 17, respectively, it would appear that photosynthesis is quite important in maintenance of desirable

oxygen levels at those localities, and the suspicion exists that extended absences of this process during low stages probably result in critical oxygen conditions from time to time.

In this time of widespread detergent use, phosphate normally achieves considerable concentration in municipal wastes, and, since it is subject to only partial removal by conventional sewage treatment practices, its presence in streams below most sewered communities is to be expected. It is frequently added to streams by laundering and similar activities in unsewered towns and villages, and can also reach streams in runoff from fertilized fields. A number of towns along the Cedar River system, especially larger ones such as Waterloo and Cedar Rapids, could be expected to contribute sufficient phosphate to assure its detection for a few river miles at discharges prevailing during the first four days of this study. Its absence in six of the sampled reaches, especially below Waterloo and Cedar Rapids (Stations 14 and 17), was not anticipated after marked contributions were noted from Northwood on the Shellrock and presumably from Mason City on the Winnebago. Trace quantities at Marble Rock and 1.0 ppm at Conger Street in Waterloo indicate that it reached the streams from the towns and municipalities and suggest that it rapidly left the free state in the stream environment. It is often rapidly consumed by algae, and it may be precipitated under certain conditions. Factors controlling its existence cannot be arrived at from a single series of samples, and the condition noted may be quite abnormal. In the absence of contrary evidence it seems safe to assume that available phosphorus is seldom scarce enough to impose alone a drastic limitation on algal growth.

Ammonia nitrogen occurred in concentrations that suggested continued contributions with downstream distance. Marked augmentation was evident only below Waterloo (Station 14). Ammonia and phosphate have similar origins in

fertilizer and sewage, but the former may also be produced by nitrification and denitrification activities in streams. Concentrations noted in these streams were adequate to support critical phytoplankton development.

Nitrite nitrogen, which is usually indicative of recent fecal contamination was found only at Marble Rock and below Waterloo. Its presence at the latter site is not noteworthy, but it was not expected at Station 7 following its absence at Stations 4 and 5. Nitrite can be produced in detectable quantities by zooplankters or massed concentrations of other aquatic animals, and such populations may have occurred at Marble Rock.

Chemical features showed a prevalent photosynthetic condition (until rain flushed the Cedar River), and a nutrient level capable of maintaining critical phytoplankton densities when physical factors favor such growths.

## BIOLOGICAL FEATURES

### Phytoplankton

Phytoplankton analyses were performed at each of the 20 stations indicated on the attached map. The three most numerous groups in descending order and total number per ml. appear in Table 3. Briefly, this table shows that the Lake Albert Lea population underwent some changes by the time it reached Station 3, was largely displaced by other forms at Station 6, and disappeared from the dominant ranks below the junction of the Shellrock and Cedar Rivers. At most stations dominance was held by diatoms, and study of Tables 3 and 4 will show that they developed independently in all rivers. They prevailed in the West Fork, in the Cedar above its junction with the West Fork and Shellrock, and in the Iowa above its union with the Cedar. In none of these places could they have been introduced by the Shellrock or the Cedar below the Shellrock, and it must be recognized that predominance of diatom

FIGURE 2. -- Station 1, Shellrock River at its exit from Lake Albert Lea.

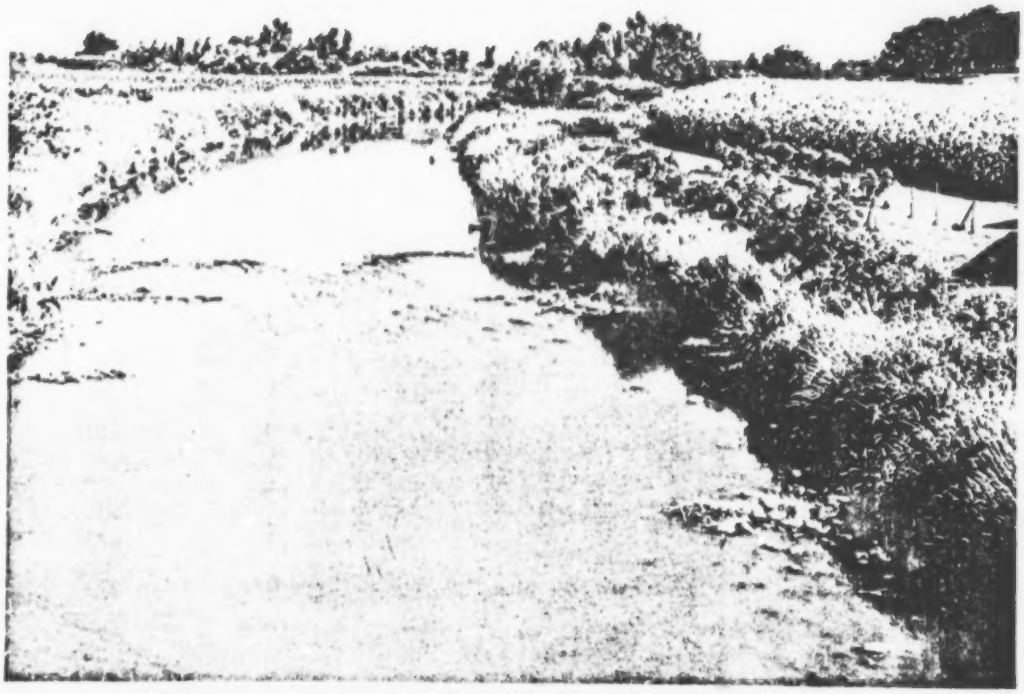


FIGURE 3. -- Station 4, Shellrock River near Northwood, Iowa.

phytoplankters probably represented a general development that was likely triggered by climatological and cyclical factors in streams of this general region. Lake Albert Lea was an exceptional habitat, but its population did not long dominate the Shellrock River.

Individual plankton analyses appear in Table 4. At Station 6 (above the Rockford Dam) and Station 7 (just below the Marble Rock Dam) samples were taken near right and left banks and at midstream to check on cross-sectional variation in and below the small impoundments. Results listed indicate the desirability of cross-sectional composites in any future phytoplankton studies of this river system. However, all segments of discharge at Stations 6 and 7 showed the same relationship to the nearest upstream station in each instance, and trends were in all likelihood correctly indicated by the midstream samples taken at all stations.

Determining the sources of various groups of plankters in a stream complex of this size can often be accomplished with a high degree of accuracy when specific identifications are available. Identification to genus or generic groups, which was imposed by time limitations and other factors here, greatly reduces accuracy, as it is then possible for distinctive groups to pass unrecognized. Entries in Table 4 clearly indicate that the Scenedesmus occurring in Lake Albert Lea found conditions in the Shellrock River more to its liking and progressively increased its concentration down to the region of Northwood (Station 4). However, it is not safe to assume from a generic determination that this same form was alone represented in Scenedesmus growths at Stations 7 and below. All Dictyosphaerium are undoubtedly of the same species, but in view of the gaps at Stations 6, 12, 13, 14, 15, and 16, it is evident that all local populations of this genus did not originate in Lake Albert Lea. Occurrence of all other green algae and euglenophytes indicated rather localized growths.

Diatoms first appeared at Station 2, where they were probably displaced from benthic growths on the low head dam and rocky bottom. The number of forms and concentration increased with distance down the Shellrock, but greater numbers developed in the Cedar (Station 9) and West Fork (Station 10) before their waters came in contact with the Shellrock discharge. It appears that diatom populations developed in response to general climatological or cyclical phenomena, and conditions in all river reaches visited during this study apparently favored their growth.

Blue-green algae occurring in Lake Albert Lea were largely displaced by Scenedesmus and diatoms above Station 4. Redevelopment of Oscillatoria below Station 7 may have been due to appearance of another species, and was in response to local conditions in any event.

The numerous small impoundments in this river system may be expected to promote localized developments, particularly during low river stages when detention times increase.

Benthic samples taken at Stations 5 and 9 showed heavy growths of Nitzschia and the Cyclotella-Stephanodiscus group and displaced benthic forms undoubtedly contributed to plankton densities. This source is particularly indicated for Gomphonema, Cymbella, Stauroneis, and Gyrosigma.

Low plankton densities at Stations 18, 19, and 20 on July 28 reflected dilution and dispersal by turbid runoff from heavy rains on July 26 and 27. Condition of the streams at these stations offered little hope of tracing plankton populations into the Mississippi and sampling of that river was omitted.

Plankton samples collected at or near these 20 stations by W. E. Smith prior to this study indicated the predominant composition for June 24 and July 11 shown in Table 5. On June 24 Oscillatoria prevailed in the Shellrock (except at Nora Springs) and in the Cedar below its junction with the Shellrock.

FIGURE 4. -- Station 5, Winnebago River at Rockford.

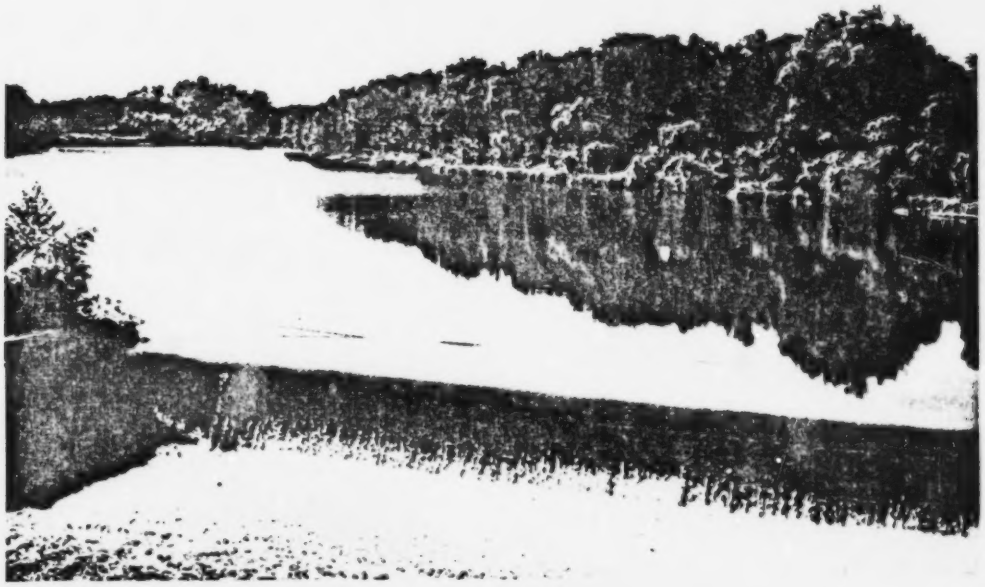


FIGURE 5. -- Station 7, Shellrock River at Marble Rock.

Although Lake Albert Lea (Station 1) was not sampled on June 24, it is reasonable to assume that Oscillatoria was its dominant phytoplankter, as its population largely maintained its numbers down to Station 4 on other occasions (July 11 and 24). It is probably also correct to believe that the same species of Oscillatoria dominated all sampled reaches in and below the Shellrock, and there is no reason to discount its introduction from Lake Albert Lea.

On July 11 the Lake Albert Lea population was declining when discharge reached Station 4 and below Station 8 plankton composition was largely dominated by diatoms, Nitzschia, Cyclotella, and the Cyclotella-Stephanodiscus group. Diatoms appeared to develop generally and were evidently not introduced by any branch or tributary sampled.

Individual plankton analyses for June 24 (Table 6a) show that Oscillatoria declined in the Shellrock River at Nora Springs, experienced a resurgence beginning at Station 7 and continuing through Palo, decreased again at Station 11, and probably continued to decline down to Station 16. On June 29 an Oscillatoria increase (6,000 to 22,000 organisms per ml) occurred between Stations 11 and 15. These events all indicate that Oscillatoria was controlled by conditions in each stream reach in which it developed, and show that its continued downstream growth, which was obscured by dilution as discharge increased, was supported by nutrient elements supplied along the courses of the streams and not by materials coming from Lake Albert Lea.

On July 11 (Table 6b) Oscillatoria declined in the Shellrock above Nora Springs, redeveloped somewhat at Clarksville and Station 8, but showed little growth in the Cedar River. Its failure to penetrate the Cedar on that date indicates the control exerted by local conditions and suggests that continued predominance of a Lake Albert Lea organism as occurred on June 24 is unusual. It is possible that resurgence of Oscillatoria at Clarksville and Station 8 on

July 11 reflected entrance of another form or species.

Diatoms, which became the dominant growth on July 11, seemingly developed independently in the Shellrock and Cedar Rivers, and considerable variation occurred among different stations on the Shellrock. The Cyclotella-Stephanodiscus group and Cyclotella were prominent diatoms as they were on July 24, 25, 26, 27, and 28.

Actinomycetes

Cultures from water and bottom samples reared by R. L. Morris, Ph.D., Iowa State Hygienic Laboratory, are listed in Table 7. July 11 samples were collected by Smith and Gerber. It appears that Streptomyces prefers a bottom habitat, but the chosen mode of life of Micromonospora is not indicated. No consistent relationship to pollution can be claimed. On July 11 Streptomyces was relatively abundant at Station 12, but was absent there on July 26; it was more concentrated at Stations 15 and 16 on July 27, but tastes and odors were more severe on July 11. Micromonospora had a generally higher concentration, and was much more widespread in early July. Streptomyces at Stations 15 and 17 on July 27 may have originated in soil or stream bottom since both localities were discolored with recent runoff.

## DISCUSSION

Evidence gained in this study indicates that all reaches of the Cedar River system above Cedar Rapids, and probably down to its junction with the Iowa River, possess the necessary nutrients and physical characteristics to support dense algal growths when climatological conditions permit. It appears that rainfall would rarely maintain turbidity and dilution at unfavorable levels for an entire growing season, and high densities should occur every year. The numerous impoundments along the major branches may be expected to emphasize local influences as detention time in them increases with low flows, and initiation

FIGURE 6. -- Station 10, West Fork of the Cedar River near Finchford.

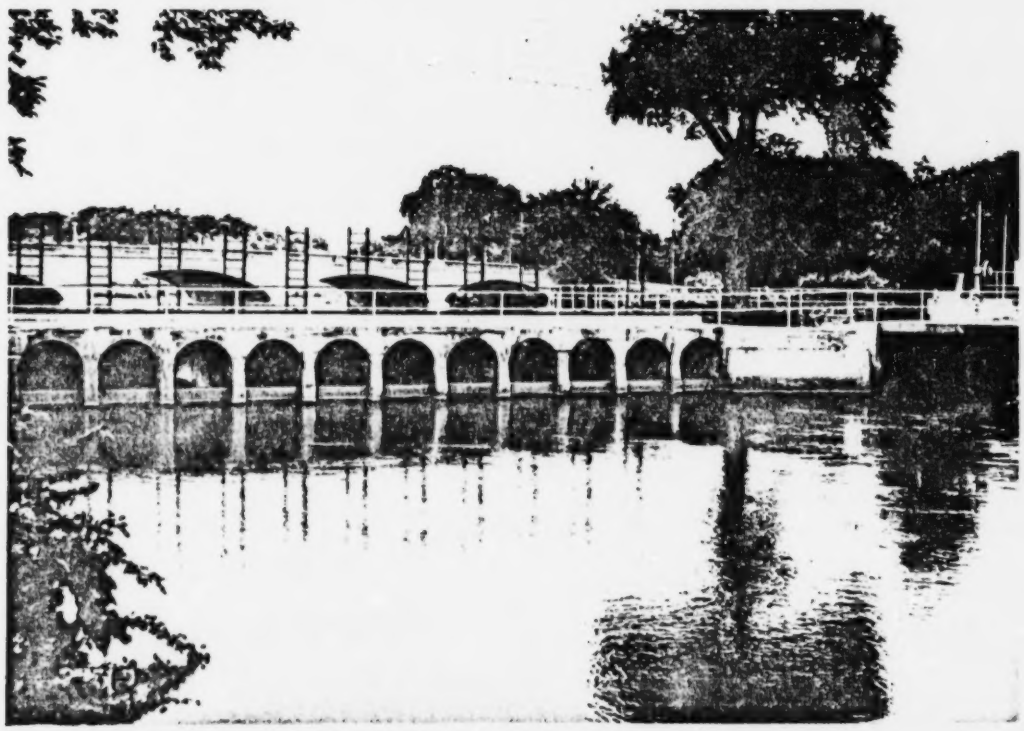


FIGURE 7. -- Station 11, Power race from Cedar River at Cedar Falls.

of a "bloom" condition in any section would not be surprising. However, it appears that the rivers often come under the domination of general phytoplankton developments that occupy streams of a wide area in response to certain climatological factors; and, under these conditions, local actions are largely restricted to determination of densities attained in individual impoundments or reaches.

Rarer and more critical nutrients for plant growth, nitrogen, phosphorus, potassium, etc., are largely supplied by surface wash of fertilized farmlands and sewage and other wastes discharged from the towns and cities. Analysis results from this study indicate that fertilizers are a reliable source of nitrogen. The larger municipalities make the greatest individual contributions of nutrient substances, but over-all quantities of certain elements originating in fertilizer may possibly have more widespread effects.

The Cedar River basin was subjected to severe flooding in late March and early April, 1961, and residual leaching of stranded materials may have increased stream productivity above normal levels.

In view of the great potential for expression of local factors, it appears unusual for the entire streams to come under the domination of a single phytoplankter entering from the headwaters. Such an occurrence was indicated by samples taken June 24, when the prevailing organism, Oscillatoria, evidently entered from Lake Albert Lea and then reacted to varying conditions in different stream reaches. Time required for this degree of dominance to become established is not known, nor are its developmental steps. Although this organism was introduced from Lake Albert Lea, its maintenance and growth in the Shellrock and Cedar Rivers was promoted by materials entering along their courses in Iowa.

The identity of organisms involved in taste and odor developments is difficult to pin down definitely from available information. It appears that

the peak undesirable condition occurred when phytoplankton growths were at or near their observed maximum, and it is definitely known that dense phytoplankton populations were present all the time the tastes and odors endured. The state of the river before and after the occurrence of this problem is not known. However, it must be assumed that conditions promoting tastes and odors were produced by the phytoplankton populations or by other developments that were also favored by the prevailing stream conditions or by the phytoplankton itself. Present knowledge makes it very difficult to ignore or discount the plankton.

The other suspected group of organisms, the Actinomycetes, were strongly favored culprits at the time of our study. However, limited background information on these and other rivers prohibits interpretation, from two series of samples, of the role of Actinomycetes in tastes and odor developments. As indicated earlier, available data on this group of fungi in the Cedar River are rather contradictory in some respects, and suggest a more important role for Micromonospora than for Streptomyces, if this group of fungi was involved in taste and odor production. It has been argued that algae give rise to unpalatable water only after they are parasitized by Actinomycetes. The belief that Actinomycetes are involved in tastes and odors is growing and spreading around the world, but many of their relationships are vague or hazy, and to date it has not been possible to discredit the belief in algal involvement.

If algae are assumed responsible for the Cedar River problem, diatoms and blue-green algae must share the responsibility as they shared dominance during the problem period.

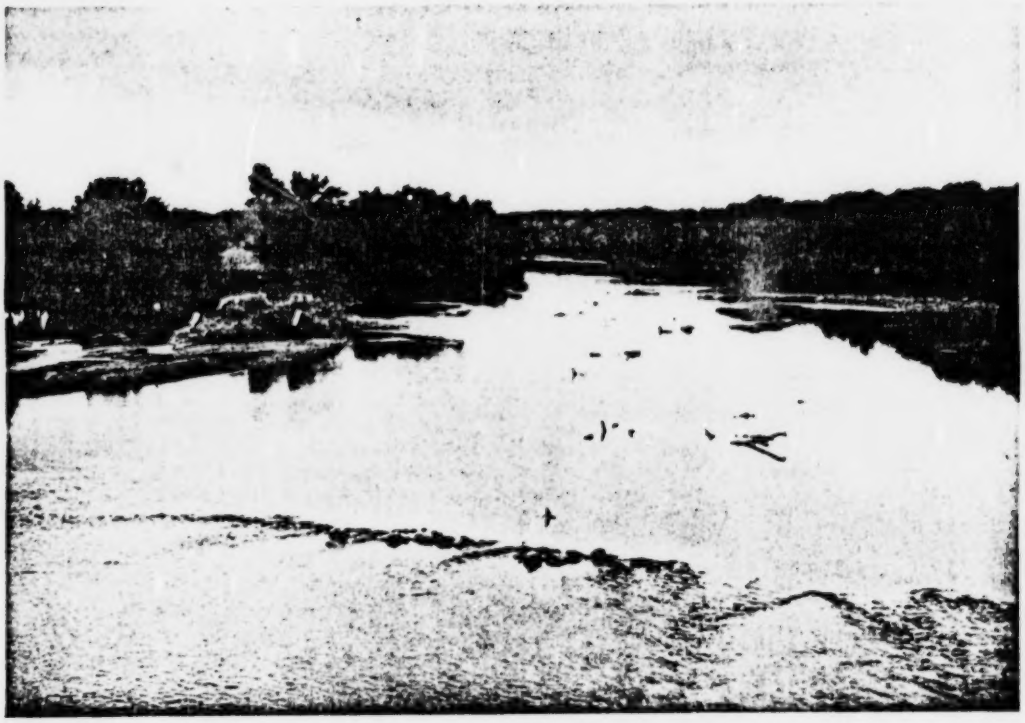


FIGURE 8. -- Station 14, Cedar River at Gilbertsville.

FIGURE 9. -- Station 18, Cedar River, shortly above its junction with the Iowa River.

## RECOMMENDATIONS

Contacts with several local residents and Cedar Rapids water plant personnel indicated that tastes and odors commonly occur in the Cedar River system. It does not appear that causes for such developments can be definitely ascertained or completely worked out from studies made only during the existence of such conditions, and a year-round study of phytoplankton and Actinomycetes, with related chemical sampling is indicated to get to the root of this matter.

This program would require definite personnel commitments, but it would appear that cooperative arrangements that could probably be made among the State Department of Health, the State Hygienic Laboratory, the Cedar Rapids water plant, and the State Conservation Department, would provide the necessary manpower without placing too heavy a drain on any single agency. Resolving this problem in the Cedar River would provide information of great value to other river systems in Iowa and surrounding states.

Plankton growth over the seasons should be related to chemical and physical conditions, and unique developments leading to tastes and odors may then be noted and evaluated. This river system offers a splendid opportunity for study of the role of Actinomycetes and continued investigation along this line is very desirable. Sampling of bottom and water on a routine basis, which may be intensified as indicated, should allow correlation with taste and odor development and indicate approaches for definite proof or refutation of their involvement.

Table 1. Stream Features at Sampling Stations

| Sta. | Width-Feet | Depth-Feet | Bottom | Color | Vegetation in Water | Banks | Surroundings | Miscellaneous | Location | Streams |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 80 | 1-3 | Soft Mud | Rusty Green | Lilies & Sago Pond Weed | Low With Cat-tails, No Trees | Lake Albert Lea Just Upstream | Pool Above Low Head Dam | Outlet to Lake Albert Lea | Shellrock River |
| 2 | 60 | 1½ | Rocks | Rusty Green | Algae & Sago Pond Weed | Trees on Right | Farmlands Just Downstream | Below a Low Head Dam | 200' Below Station 1 | Shellrock River |
| 3 | 40 | 3 | Soft Mud | Rusty Green | None Noted | Tree-Lined Marginal Grasses | Open Farmlands | Black Flocculent Layer on Bottom | U. S. Highway 65 Bridge | Shellrock River |
| 4 | 55 | 1 | Rocks & Silt | Rusty Green | None Noted | Tree-Lined Marginal Grasses | Open Farmlands Town on Left | --- | ½ mile West of Northwood | Shellrock River |
| 5 | 150 | 2 | Rocks, Sand, Silt | Murky Brown | Green Algae & Diatoms | Tree-Lined With Weeds & Willows | Open Fields | --- | Near Rockford | Winnebago River |
| 6 | 200 | 1-3 | Not Observable | Light Green | None Noted | Tree-Lined | Edge of Town Residential Area | Low Head Dam 100 yds. Below | In Rockford | Shellrock River |
| 7 | 240 | 4-6 | Rocks | Murky Brown | Diatoms, Blue-Green, Green Algae | Tree-Lined | At Edge of Town | Low Head Dam Just Upstream | At Marblerock | Shellrock River |
| 8 | 200 | 1-3 | Rocks, Silt, Gravel | Grayish Green | Green Algae on Dam | Tree-Lined Marginal Weeds & Willows | In Small Town | Below a Low Head Dam | At Shell Rock | Shellrock River |
| 9 | 260 | 1-2 | Rocks, Silt, Sand | Murky Brown | None Noted | Tree-Lined | Open Farmlands | Low Head Dam 100 yds. Below | At Janesville | Cedar River |
| 10 | 150 | 1-2 | Silt, Sand, Driftwood | Brown | None Noted | Tree-Lined Marginal Grasses & Willows | Open Farmlands | --- | Near Finchford | West Fork Cedar Rive |

Table 1. Stream Features at Sampling Stations
(cont'd)

| Sta. | Width-Feet | Depth-Feet | Bottom | Color | Vegetation in Water | Banks | Surroundings | Miscellaneous | Location | Streams |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 100 | 6 | Sand | Brown | None Noted | Tree-Lined | In City | Inchannel Diverted to Power Plant | In Cedar Falls | Cedar River |
| 12 | 350 | >6 | Unknown | Brown | None Noted | Tree-Lined Houses at Margin | In City | In an Impoundment | Conger St. Bridge, Waterloo | Cedar River |
| 13 | 60 | 2 | Sand & Silt | Dingy | None Noted | Weeds & Willows at Margins Tree-Lined | Open Farmlands | --- | South of Waterloo | Blackhawk Creek |
| 14 | 525 | 3 | Stones, Sand, Driftwood | Murky Green | None Noted | Tree-Lined | Farmlands, Town on Left | Numerous Small Islands | At Gilbertsville | Cedar River |
| 15 | 550 | 1-2 | Sand, Driftwood | Turbid | None Noted | Tree-Lined | Open Farmlands | Numerous Sand Bars & Small Islands | At Vinton | Cedar River |
| 16 | 600 | >30 | Unknown | Brown | None Noted | Tree-Lined | Wooded Hills on Left, Open Farmlands on Right | Impounded | Cedar Rapids Water Intake | Cedar River |
| 17 | 480 | 4 | Sand & Mud | Greenish Brown | None Noted | Weeds & Willows Tree-Lined | Woods on Left Open Farmlands on Right | One Island Below Bridge | U. S. Highway 30 Bridge | Cedar River |
| 18 | 720 | 3 | Mud & Sand | Turbid | None Noted | Tree-Lined Weeds & Willows | Open Farmlands | Island Near Center | Highway C Bridge, Muscatine Co. | Cedar River |
| 19 | 250 | 3 | Mud & Sand | Turbid | None Noted | Willows & Weeds Tree-Lined | Open Farmlands | Above Mouth of Cedar River | Highway 76 Crossing North of Columbus Junction | Iowa River |
| 20 | 840 | 1½ | Mud & Sand | Turbid | None Noted | Willows & Weeds Weeds At Margins Tree-Lined | Open Farmlands and Wood Lots | Below Mouth of Cedar River | Highway 92 Bridge | Iowa River |

Table 2. Chemical Features At Selected Stations

| Station | Temp. °C | pH | $CO_3$ Alk. | $HCO_3$ Alk. | $O_2$ | $PO_4$ | $NH_3$-N | $NO_2$-N | Date |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 28 | 9.6 | 88 | 4 | 15.2 | <1.0 | 0.25 | 0.0 | 7/24/61 |
| 4 | 21 | 8.3 | 12 | 109 | 9.2 | 3.0 | 0.15 | 0.0 | 7/25/61 |
| 5 | 26 | 8.2 | 12 | 250 | 10.4 | 3.0 | 0.25 | 0.0 | 7/25/61 |
| 7 | 26 | 8.5 | 20 | 180 | 9.6 | Tr. | 0.25 | 0.01 | 7/25/61 |
| 8 | 26 | 8.75 | 40 | 120 | 12.8 | 0.0 | 0.30 | 0.0 | 7/25/61 |
| 9 | 25 | 8.8 | 32 | 155 | 9.4 | 0.0 | 0.20 | 0.0 | 7/26/61 |
| 10 | 28 | 9.0 | 48 | 142 | 16.0 | 0.0 | 0.25 | 0.0 | 7/26/61 |
| 11 | 26 | 8.5 | 24 | 150 | 11.2 | 0.0 | 0.25 | 0.0 | 7/26/61 |
| 12 | 26 | 8.7 | 32 | 126 | 12.4 | 1.0 | 0.35 | 0.0 | 7/26/61 |
| 14 | 26 | 7.9 | 0.0 | 156 | 4.9 | 0.0 | 0.70 | 0.025 | 7/27/61 |
| 16 | 27 | 8.15 | -- | --- | ---- | --- | ---- | ---- | 7/27/61 |
| 17 | 28 | 7.7 | 0.0 | 124 | 4.0 | 0.0 | 0.30 | 0.0 | 7/27/61 |

## Table 3. Dominant Phytoplankters and Total No. Organisms per ml.

| Station 1 | 2 | 3 | 4 | 5 | 6L | 6C |
|---|---|---|---|---|---|---|
| Shellrock River | Shellrock River | | | | | |
| Oscillatoria | Oscillatoria | Oscillatoria | Oscillatoria | Nitzschia | Nitzschia | Scenedesmus |
| Microcystis | Microcystis | Scenedesmus | Scenedesmus | Cyclo.-Steph. | Scenedesmus | Nitzschia |
| Scenedesmus | Scenedesmus | Chlorella | Nitzschia | Melosira | Oscillatoria | Oscillatoria |
| | | | | | Microcystis | |
| 51,700 | 55,900 | 65,750 | 41,300 | 2,100 | 8,400 | 4,750 |

| Station 6R | 7L | 7C | 7R | 8 | 9 | 10 |
|---|---|---|---|---|---|---|
| Scenedesmus | Nitzschia | Nitzschia | Nitzschia | Cyclo.-Steph. | Cyclo.-Steph. | Cyclo.-Steph. |
| Nitzschia | Scenedesmus | Scenedesmus | Scenedesmus | Oscillatoria | Nitzschia | Cyclotella sp. |
| Cyclo.-Steph. | Cyclo.-Steph. | Cyclo.-Steph. | Cyclo.-Steph. | Nitzschia | Cyclotella sp. | Nitzschia |
| Oscillatoria | | | | | | |
| 5,600 | 12,300 | 24,750 | 20,950 | 26,570 | 24,390 | 67,500 |

| Station 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|
| Cyclo.-Steph. | Cyclo.-Steph. | Nitzschia | Cyclo.-Steph. | Cyclo.-Steph. | Cyclotella sp. | Cyclo.-Steph. |
| Nitzschia | Cyclotella sp. | Stauroneis | Cyclotella sp. | Nitzschia | Cyclo.-Steph. | Cyclotella sp. |
| Oscillatoria | Nitzschia | Navicula | Nitzschia | Scenedesmus | Scenedesmus | Nitzschia |
| 52,400 | 24,075 | 900 | 28,850 | 15,900 | 14,800 | 23,650 |

| Station 18 | 19 | 20 |
|---|---|---|
| Cyclo.-Steph. | Nitzschia | Nitzschia |
| Melosira | Cyclo.-Steph. | Cyclo.-Steph. |
| Nitzschia | Melosira | Melosira |
| 2,150 | 3,050 | 4,450 |

Table 4. Individual Plankton Analyses, Figures Indicate No. per Milliliter of River Water

| Sta. | 1 | 2 | 3 | 4 | 5 | 6 Left | 6 Center | 6 Right | 7 Left | 7 Center | 7 Right | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Green Algae** | | | | | | | | | | | | |
| **Chlorophyceae** | | | | | | | | | | | | |
| **Chlorococcales** | | | | | | | | | | | | |
| Scenedesmus sp. | 3,500 | 5,500 | 8,000 | 15,000 | 200 | 2,500 | 2,200 | 3,000 | 1,800 | 6,500 | 6,000 | 2,000 |
| Dictyosphaerium | 750 | 600 | 250 | 150 | | | | | 50 | 250 | | 250 |
| Pediastrum | 200 | 100 | | | | | | | | | | |
| Golenkinia | 450 | 400 | 750 | 900 | | 200 | 300 | 250 | 750 | 850 | 400 | 200 |
| Chlorella | | | 4,500 | 500 | | | | | | | | |
| Actinastrum | | | 100 | | | | | | 50 | 150 | | 450 |
| Micractinium | | | | 600 | 100 | | | | | 350 | | 150 |
| Ankistrodesmus | | | 200 | | | 350 | 200 | | 100 | | 400 | |
| Lagerheimia | | | | | | 350 | | | 200 | 250 | 100 | |
| Closteriopsis | | | | | | | | 50 | | | | |
| Tetraedron | | | | | | | | | | | | 50 |
| **Tetrasporales** | | | | | | | | | | | | |
| Gloeocystis | 400 | 450 | | | | | | | | | | |
| Sphaerocystis | | | | | | 200 | 200 | | 200 | 200 | 150 | 200 |
| **Volvocales** | | | | | | | | | | | | |
| Chlamydomonas | | | | | | | | | | | | |
| Pandorina | | | | | 50 | | | | | | | 50 |
| Eudorina | | | | | | | | | | | | |
| **Zygnematales** | | | | | | | | | | | | |
| Staurastrum | | 100 | 150 | 50 | | | | | | 300 | | |
| Closterium | | | | | | | | | | | | |
| **Euglenophyta** | | | | | | | | | | | | |
| **Euglenales** | | | | | | | | | | | | |
| Euglena | | | | | | 400 | 50 | 150 | 50 | 100 | | |
| Trachelomonas | | | | | | | | | | | 50 | |
| **Yellow Green Algae** | | | | | | | | | | | | |
| **Bacillariophyceae** | | | | | | | | | | | | |
| **Centrales** | | | | | | | | | | | | |
| Cyclo.-Steph. gr. | | | | 850 | 400 | 200 | 250 | 400 | 1,200 | 6,000 | 3,500 | 11,500 |
| Cyclotella sp. | | 2,500 | 1,500 | 1,000 | | 150 | | 100 | 200 | 200 | 150 | 2,520 |
| Melosira | | | | 300 | 250 | 50 | | | 250 | 100 | 250 | 850 |
| Anacystis | | | | | | | | | | | | |
| **Pennales** | | | | | | | | | | | | |
| Nitzschia | | | 850 | 2,000 | 800 | 3,500 | 850 | 450 | 6,500 | 8,000 | 8,000 | 3,500 |
| Navicula | | | 1,000 | 350 | 150 | 250 | | 200 | | 150 | 150 | |

Table 4. Individual Plankton Analyses, Figures Indicate No. per Milliliter of River Water

| Sta. | 1 | 2 | 3 | 4 | 5 | 6 Left | 6 Center | 6 Right | 7 Left | 7 Center | 7 Right | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pennales (cont'd) | | | | | | | | | | | | |
| Synedra | | | | | | 100 | | | 150 | | | 150 |
| Gomphonema | | | | | | | | 50 | | | | |
| Cymbella | | | | | | | | | | 500 | 500 | |
| Stauroneis | | | | | | | | | | 200 | | 100 |
| Gyrosigma | | | | | | | | | | | | |
| Blue-Green Algae | | | | | | | | | | | | |
| Chroococcales | | | | | | | | | | | | |
| Dactylococcopsis | | | 100 | | | 200 | 150 | 350 | 150 | 350 | 350 | |
| Microcystis | 12,000 | 9,500 | 3,000 | 1,500 | | 400 | 50 | 200 | 150 | 300 | 100 | 200 |
| Oscillatoriales | | | | | | | | | | | | |
| Oscillatoria | 34,000 | 35,000 | 43,000 | 18,000 | 150 | 400 | 350 | 400 | 100 | 300 | 350 | 4,000 |
| Aphanizomenon | 300 | 1,750 | 2,000 | | | 150 | 150 | | | | 450 | 400 |
| Anabaena | 100 | | 350 | 100 | | | | | | 150 | | |
| Total | 51,700 | 55,900 | 65,750 | 41,300 | 2,100 | 8,400 | 4,750 | 5,600 | 12,300 | 24,750 | 20,950 | 26,570 |

Table 4. Individual Plankton Analyses, Figures Indicate No. per Milliliter of River Water

| Sta. | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GreenAlgae | | | | | | | | | | | | |
| Chlorophyceae | | | | | | | | | | | | |
| Chlorococcales | | | | | | | | | | | | |
| Scenedesmus sp. | 100 | 100 | 1,350 | 3,000 | | 1,100 | 2,500 | 2,000 | 3,000 | 100 | 50 | |
| Dictyosphaerium | 50 | 50 | 50 | | | | | | 200 | 100 | | |
| Pediastrum | | 50 | | 50 | | | 50 | 50 | 250 | | 50 | |
| Golenkinia | 300 | | | 150 | | | | 300 | | 100 | | |
| Chlorella | | | | | | | | | | | | |
| Actinastrum | 100 | 100 | 350 | 150 | | 250 | 100 | 250 | 350 | 200 | | 300 |
| Micractinium | 40 | | 250 | 50 | | | | 100 | 150 | | | |
| Closteriopsis | | | 50 | | | | | | | | | |
| Tetraedron | | | | 50 | | | | | | | | |
| Tetrasporales | | | | | | | | | | | | |
| Gloeocystis | 100 | | | 100 | | | | | 200 | | 50 | 50 |
| Sphaerocystis | | | | | | | | 100 | | | | |
| Volvocales | | | | | | | | | | | | |
| Chlamydomonas | | | 50 | | | | | | | | | |
| Eudorina | 50 | | | | | | | 50 | | | | |
| Zygnematales | | | | | | | | | | | | |
| Staurastrum | | | | | | | | 150 | | | | |
| Closterium | | | | 25 | | | | | | | | |
| Euglenophyta | | | | | | | | | | | | |
| Euglenales | | | | | | | | | | | | |
| Euglena | 150 | 100 | 250 | 50 | | 50 | | | 50 | 150 | 150 | 250 |
| Trachelomonas | | | | | | | 50 | 350 | | | | |
| Yellow Green Algae | | | | | | | | | | | | |
| Bacillariophyceae | | | | | | | | | | | | |
| Centrales | | | | | | | | | | | | |
| Cyclo.-Steph.gr. | 19,000 | 56,000 | 42,000 | 18,000 | | 14,000 | 5,000 | 3,000 | 9,000 | 500 | 750 | 450 |
| Cyclotella sp. | 1,000 | 8,500 | 1,200 | 5,000 | | 6,000 | 1,500 | 5,500 | 4,500 | | | |
| Melosira | 150 | 50 | 200 | 400 | | 450 | 350 | 300 | 250 | 350 | 300 | 350 |
| Pennales | | | | | | | | | | | | |
| Nitzschia | 2,500 | 2,000 | 4,500 | 3,500 | 650 | 4,500 | 4,500 | 400 | 4,000 | 250 | 1,200 | 2,500 |
| Navicula | 200 | 350 | | | 100 | 100 | 100 | | | | 50 | 200 |
| Synedra | | | 100 | 250 | 150 | 250 | 150 | 250 | 250 | 150 | 150 | 50 |
| Stauroneis | 50 | | 200 | 100 | | | | | | 50 | 100 | 150 |
| Gyrosigma | | 50 | | | | | 150 | | | 50 | 200 | 150 |

Table 4. Individual Plankton Analyses, Figures Indicate No. per Milliliter of River Water

| Sta. | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Blue-Green Algae | | | | | | | | | | | | |
| Chroococcales | | | | | | | | | | | | |
| Dactylococcopsis | | 150 | | 100 | | | | 250 | | | | |
| Microcystis | | | | | | | | | | 100 | | |
| Oscillatoriales | | | | | | | | | | | | |
| Oscillatoria | 100 | | 1,500 | 2,650 | | 2,150 | 1,300 | 1,650 | 1,150 | 50 | | |
| Aphanizomenon | 450 | | 350 | 450 | | | 150 | 100 | 300 | | | |
| Totals | 24,390 | 67,500 | 52,400 | 24,075 | 900 | 28,850 | 15,900 | 14,800 | 23,650 | 2,150 | 3,050 | 4,450 |

Table 5. Dominant Phytoplankters and Total No. of Organisms per ml.
(Stations 1 - 13)

| June 24, 1961 | Station 1 | Station 3 | Station 4 | Nora Springs | Station 6 | Station 7 | Clarksville |
|---|---|---|---|---|---|---|---|
| | | | Oscillatoria | Scenedesmus | | Oscillatoria | Oscillatoria |
| | | | Scenedesmus | Oscillatoria | | Scenedesmus | Scenedesmus |
| | | | Microcystis | Synedra | | Synedra | Synedra |
| | | | 61,250 | 27,800 | | 21,700 | 28,250 |
| July 11, 1961 | Oscillatoria | Oscillatoria | Oscillatoria | Scenedesmus | Scenedesmus | Scenedesmus | Scenedesmus |
| | Microcystis | Microcystis | Scenedesmus | Melosira | Melosira | Synedra | Oscillatoria |
| | Scenedesmus | Scenedesmus | Nitzschia | Nitzschia | Euglena | Oscillatoria | Synedra |
| | 75,650 | 79,050 | 52,100 | 20,200 | 4,750 | 3,350 | 15,750 |

| June 24, 1961 | Station 8 | Station 9 | Station 10 | Palo | Station 11 | Station 12 | Station 13 |
|---|---|---|---|---|---|---|---|
| | Oscillatoria | Scenedesmus | Nitzschia | Oscillatoria | Oscillatoria | | |
| | Scenedesmus | Pediastrum | Cyclo.-Steph. | Synedra | Synedra | | |
| | Synedra | Micractinium | Scenedesmus | Golenkinia | Melosira | | |
| | 30,150 | 850 | 7,205 | 57,950 | 19,550 | | |
| July 11, 1961 | Oscillatoria | Cyclotella | | Scenedesmus | Nitzschia | Cyclo.-Steph. | Nitzschia |
| | Scenedesmus | Nitzschia | | Cyclotella | Cyclotella | Cyclotella | Synedra |
| | Melosira | Golenkinia | | Cyclo.-Steph. | Cyclo.-Steph. | Nitzschia | Navicula |
| | 10,100 | 2,125 | | 14,550 | 12,450 | 11,750 | 20,800 |

Table 5. (cont'd) Dominant Phytoplankters and Total No. of Organisms per ml.
(Stations 14-19)

| | Station 14 | Station 15 | Station 16 | Station 19 |
|---|---|---|---|---|
| June 24, 1961 | | | Oscillatoria<br>Synedra<br>Golenkinia<br><br>19,100 | |
| July 11, 1961 | Cyclo.-Steph.<br>Cyclotella<br>Nitzschia<br><br>9,650 | Cyclotella<br>Cyclo.-Steph.<br>Nitzschia<br><br>24,500 | | Nitzschia<br>Actinastrum<br>Melosira<br><br>1,350 |

Table 6a. Individual Plankton Analyses - June 24, 1961

| | Station 4 | Nora Springs | 7 | Clarksville | 8 | 9 | 10 | Palo | 11 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Green Algae** | | | | | | | | | | |
| Chlorophyceae | | | | | | | | | | |
| Chloroccales | | | | | | | | | | |
| Scenedesmus sp. | 25,000 | 10,000 | 2,150 | 1,800 | 2,000 | 250 | 2,000 | 1,300 | | 500 |
| Dictyosphaerium | | 150 | | | | | | | | 150 |
| Pediastrum | 550 | 250 | 200 | 150 | 100 | 150 | 100 | 250 | | 100 |
| Golenkinia | | | | 200 | | 250 | 450 | | | 3,500 |
| Actinastrum | | 50 | 150 | 100 | 50 | 50 | 200 | 1,600 | | 350 |
| Micractinium | | | | | 100 | 200 | 250 | 350 | | 450 |
| Ankistrodesmus | 350 | | | 300 | 350 | | | 400 | | |
| Coelosphaerium | | 100 | | | | | | | | |
| Zygnematales | | | | | | | | | | |
| Staurastrum | 100 | | | 50 | 250 | | 150 | | | |
| Closterium | | | | | | 50 | | 100 | | |
| **Euglenophyta** | | | | | | | | | | |
| Euglenales | | | | | | | | | | |
| Euglena | | | | | | | 200 | | | |
| **Yellow Green Algae** | | | | | | | | | | |
| Bacillariophyceae | | | | | | | | | | |
| Centrales | | | | | | | | | | |
| Cyclo.-Steph. gr | | | | | | | 2,755 | | | |
| Cyclotella sp. | | | | | | | | 1,150 | | |
| Melosira | | 850 | 250 | 550 | 1,050 | 50 | 100 | 450 | 450 | 1,100 |
| Anacystis | 1,950 | 200 | 200 | 200 | 200 | | | 200 | 200 | 200 |
| Pennales | | | | | | | | | | |
| Nitzschia | 200 | | 100 | 100 | 300 | | 3,600 | 350 | 200 | |
| Navicula | | | | 150 | 100 | | 50 | 200 | 250 | |
| Synedra | 750 | 7,500 | 1,850 | 1,500 | 1,150 | 100 | 150 | 7,500 | 2,500 | 3,750 |
| Gomphonema | 50 | | | | | | | | | |
| Cymbella | 50 | | | | | | | | | |
| Stauroneis | 200 | 200 | 350 | | | | 200 | | 100 | |
| Gyrosigma | 50 | | | | | | | | | |
| **Blue Green Algae** | | | | | | | | | | |
| Oscillatoriales | | | | | | | | | | |
| Oscillatoria | 32,000 | 8,500 | 16,000 | 23,000 | 24,500 | | | 44,000 | 12,500 | 9,000 |
| Aphanizomenon | | 100 | 150 | 150 | | | | | 200 | |
| Total | 61,250 | 27,800 | 21,700 | 28,250 | 30,150 | 850 | 7,205 | 57,950 | 16,550 | 19,100 |

## Table 6b. Individual Plankton Analyses - July 11, 1961

| Station | 1 | 3 | 4 | Nora Springs | 6 | 7 | Clarksville | 8 | 9 | Palo | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Green Algae** | | | | | | | | | | | | |
| **Chlorophyceae** | | | | | | | | | | | | |
| Chloroccales | | | | | | | | | | | | |
| Scenedesmus sp. | 7,500 | 9,500 | 17,000 | 16,000 | 3,550 | 2,250 | 3,000 | 1,700 | 100 | 5,050 | 450 | 1,250 |
| Dictyosphaerium | | | 500 | | | | 50 | 50 | 50 | | | |
| Pediastrum | 150 | 150 | 100 | | 50 | 50 | | 100 | | 100 | | |
| Actinastrum | | | | | | | 200 | 250 | 50 | 950 | | 200 |
| Micractinium | | | | | | | | | 150 | 300 | | |
| Tetrasporales | | | | | | | | | | | | |
| Gloecystis | | | | | | | | | 50 | 100 | | |
| Volvocales | | | | | | | | | | | | |
| Pandorina | | | | | | | | | 75 | | | |
| Zygnematales | | | | | | | | | | | | |
| Staurastrum | | | 350 | 250 | | | | | | | | |
| **Euglenophyta** | | | | | | | | | | | | |
| Euglenales | | | | | | | | | | | | |
| Euglena | | | 50 | 100 | 350 | | 250 | 200 | | | 150 | |
| **Yellow Green Algae** | | | | | | | | | | | | |
| Bacillariophyceae | | | | | | | | | | | | |
| Centrales | | | | | | | | | | | | |
| Cyclo.-Steph.gr. | | | | | | | | | 100 | 2,500 | 3,000 | 3,500 |
| Cyclotella sp. | | | 750 | 1,850 | 400 | | 450 | 550 | 650 | 3,000 | 3,500 | 3,000 |
| Melosira | | | | | | 200 | 2,000 | 650 | 150 | 850 | | 500 |
| Anacystis | 31,000 | 10,000 | 1,550 | 550 | 50 | 100 | 100 | | | | 100 | |
| Pennales | | | | | | | | | | | | |
| Nitzschia | | 250 | 1,800 | 600 | 100 | 150 | 650 | 300 | 400 | 200 | 5,000 | 2,500 |
| Navicula | | 100 | 450 | | | 50 | | | 100 | | | |
| Synedra | | | 300 | 550 | 250 | 400 | 2,500 | 800 | | 400 | 250 | 350 |
| Gomphonema | | | 150 | | | | | | | | | |
| Cymbella | | 50 | 100 | | | | | | | | | |
| Stauroneis | | | | | | | 50 | | | 100 | | 50 |
| Gyrosigma | | | | | | | | | | | | |
| **Blue-Green Algae** | | | | | | | | | | | | |
| Chroococcales | | | | | | | | | | | | |
| Dactylococcopsis | | | | | | | | | 50 | | | |
| Oscillatoriales | | | | | | | | | | | | |
| Oscillatoria | 37,000 | 59,000 | 29,000 | 300 | 250 | 250 | 6,500 | 5,500 | | 750 | | 450 |
| Aphanizomenon | | | | | | | | | 100 | 250 | | |
| **Totals** | 75,650 | 79,050 | 52,100 | 20,200 | 4,750 | 3,350 | 15,750 | 10,100 | 2,125 | 14,550 | 12,450 | 11,750 |

Table 6b. (cont'd) Individual Plankton Analyses - July 11, 1961

| Station | 13 | 14 | 15 | 19 |
|---|---|---|---|---|
| **Green Algae** | | | | |
| **Chlorophyceae** | | | | |
| **Chloroccales** | | | | |
| **Scenedesmus sp.** | | 650 | 5,000 | |
| **Dictyosphaerium** | | | | |
| **Pediastrum** | | 150 | 50 | |
| **Actinastrum** | | 100 | | 300 |
| **Micractinium** | | | | |
| **Closteriopsis** | | 50 | | <50 |
| **Tetrasporales** | | | | |
| **Gloecystis** | | 50 | | |
| **Volvocales** | | | | |
| **Pandorina** | | | | |
| **Zygnematales** | | | | |
| **Staurastrum** | | | | |
| **Euglenophyta** | | | | |
| **Euglenales** | | | | |
| **Euglena** | 150 | | 50 | <50 |
| **Yellow Green Algae** | | | | |
| **Bacillariophyceae** | | | | |
| **Centrales** | | | | |
| **Cyclo.-Steph. gr.** | | 3,000 | 6,500 | |
| **Cyclotella sp.** | | 2,500 | 8,000 | |
| **Melosira** | | 350 | 950 | 150 |
| **Pennales** | | | | |
| **Nitzschia** | 20,000 | 1,500 | 4,000 | 650 |
| **Navicula** | 150 | | | |
| **Synedra** | 350 | 250 | 200 | 100 |
| **Gomphonema** | | | | |
| **Cymbella** | | | | |
| **Stauroneis** | 50 | | | |
| **Gyrosigma** | 100 | | | |
| **Blue-Green Algae** | | | | |
| **Chroococcales** | | | | |
| **Dactylococcopsis** | | | | |
| **Oscillatoriales** | | | | |
| **Oscillatoria** | | 1,050 | 550 | 50 |
| **Aphanizomenon** | | | | |
| **Totals** | 20,800 | 9,650 | 25,300 | <1,350 |

Table 7. Actinomycetes Cultured From Water and Bottom Samples
(Numbers indicate organisms per ml.)

| Station | Streptomyces | | Micromonospora | |
|---|---|---|---|---|
| | 7/11 | 7/24-27 | 7/11 | 7/24-27 |
| 1 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |
| 4(Bottom) | | 22 | | 0 |
| 5 | | 4 | | 0 |
| 6 | 0 | 5 | 0 | 0 |
| 7 | 0 | 1 | 3 | 0 |
| 8 | 0 | 0 | 0 | 0 |
| 9 | 5 | 0 | 0 | 0 |
| 9 (Bottom) | | 40 | | 0 |
| 10 | 0 | 8 | 0 | 0 |
| 11 | 0 | 9 | 0 | 0 |
| 12 | 27 | 0 | 28 | 0 |
| 13 | 0 | 9 | 8 | 0 |
| 14 | 0 | 1 | 0 | 0 |
| 15 | 5 | 16 | 10 | 0 |
| 16 | 12 | 22 | 20 | 10 |
| 17 | | 24 | | 10 |